Fuel delivery rail assembly for i.c. engine fuel injection

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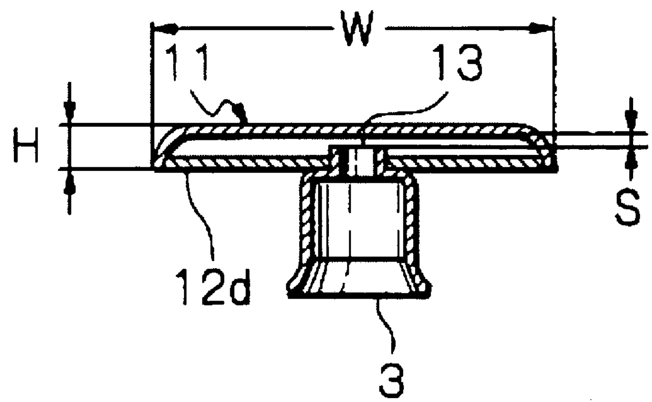
Abstract of **GB2346931**

The fuel rail 1, for electronic gasoline injection systems, comprises an elongate conduit 11, a fuel inlet pipe 2 and a plurality of sockets 3 for receiving the injectors. In cross-section, the walls of the conduit 11 include a flat or arcuate pressure-absorbing or shock-absorbing part 12a which faces the inlet ports 13 of the sockets 3 and which is smoothly and integrally connected to further pressure-absorbing or shock-absorbing parts 12b, 12c. Various rail cross-sections are disclosed, including that of a traditional telephone handset (fig.5A), a hollow "T" (fig.5B), dumbbell, fig.5D or an inverted eye mask (fig.7). Alternatively, fig.8, the rail may be circular or rectangular in cross-section, with a thin, flexible upper surface 82a and a rigid bottom plate 82b, and be provided with a flexible end-cap 85.



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(54) Abstract Title

Fuel delivery rail assembly for i.c. engine fuel injection

(57) The fuel rail 1, for electronic gasoline injection systems, comprises an elongate conduit 11, a fuel inlet pipe 2 and a plurality of sockets 3 for receiving the injectors. In cross-section, the walls of the conduit 11 include a flat or arcuate pressure-absorbing or shock-absorbing part 12a which faces the inlet ports 13 of the sockets 3 and which is smoothly and integrally connected to further pressure-absorbing or shock-absorbing parts 12b, 12c. Various rail cross-sections are disclosed, including that of a traditional telephone handset (fig.5A), a hollow "T" (fig.5B), dumbbell, fig.5D or an inverted eye mask (fig.7). Alternatively, fig.8, the rail may be circular or rectangular in cross-section, with a thin, flexible upper surface 82a and a rigid bottom plate 82b, and be provided with a flexible end-cap 85.

Fig. 2(A)

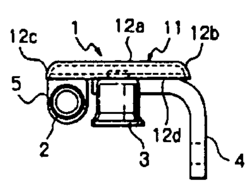

Fig. 8

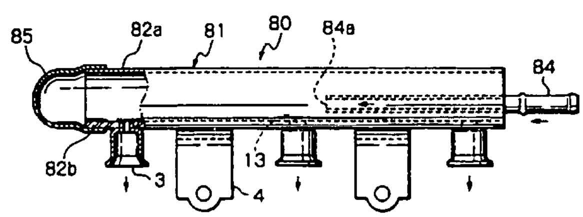

Fig. 5(D)

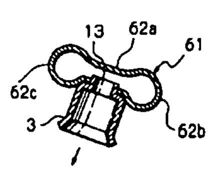

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Fig. 1

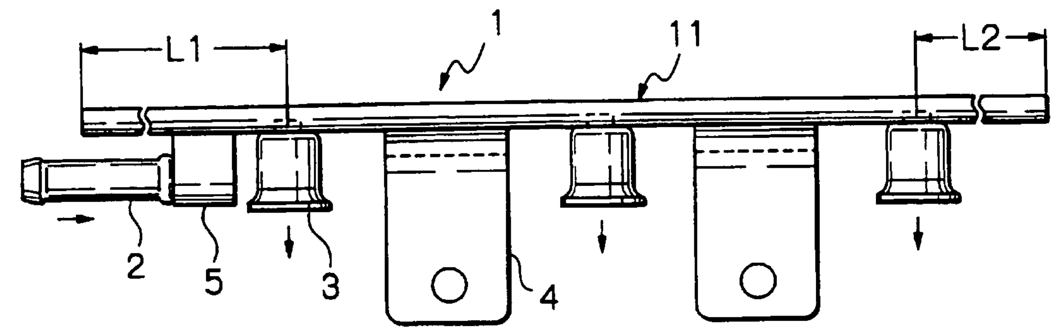


Fig. 2(A)

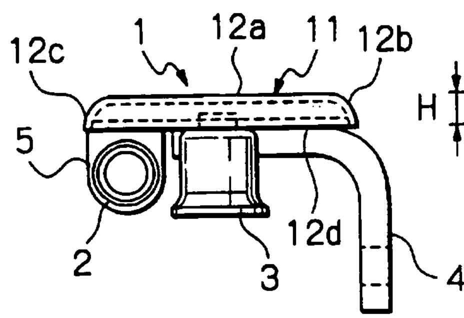


Fig. 2(B)

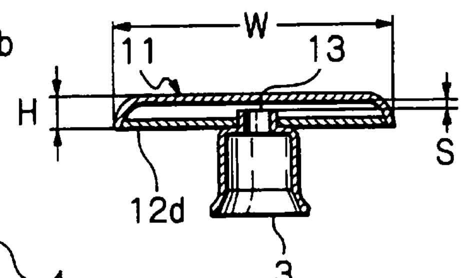


Fig. 3

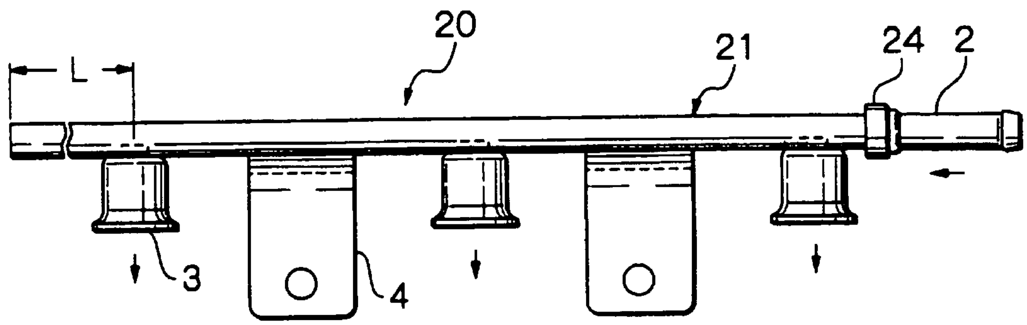


Fig. 4(A)

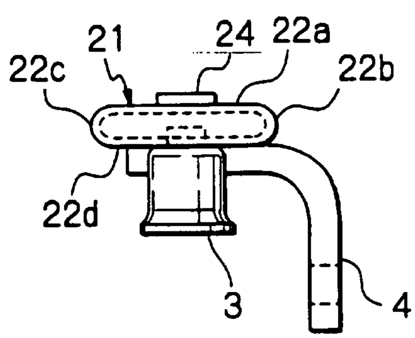


Fig. 4(B)

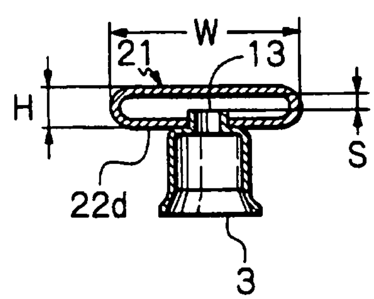


Fig. 5(A)

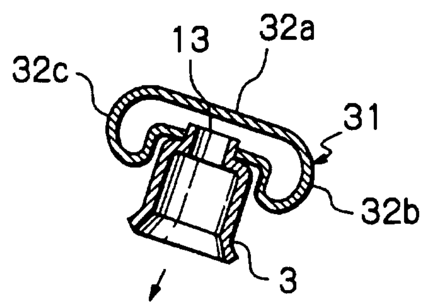


Fig. 5(B)

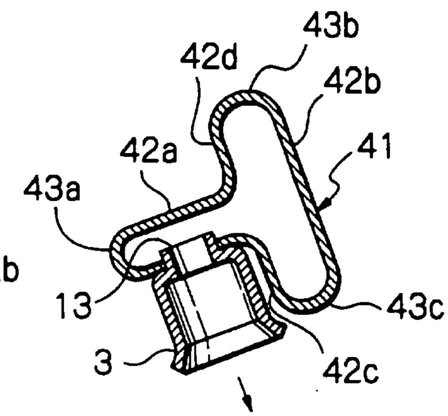


Fig. 5(C)

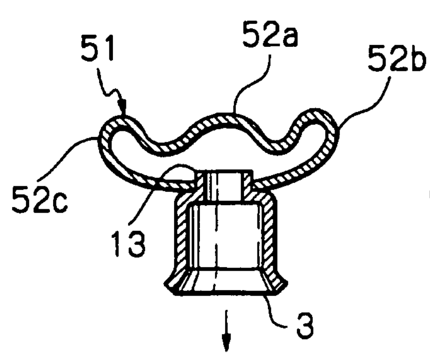


Fig. 5(D)

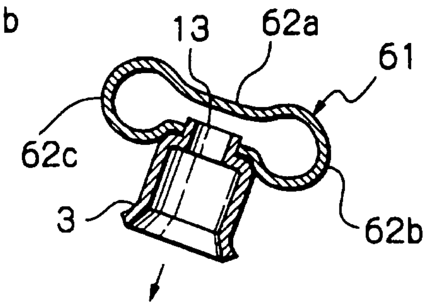


Fig. 6

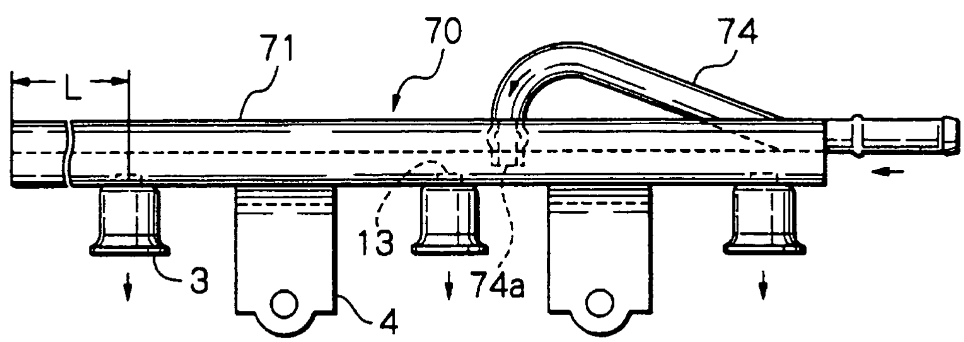


Fig. 7

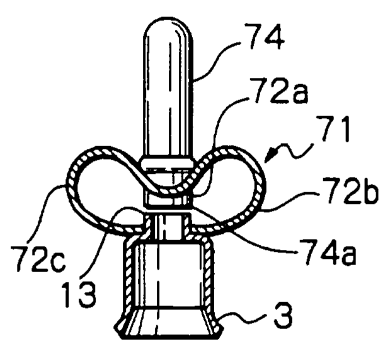
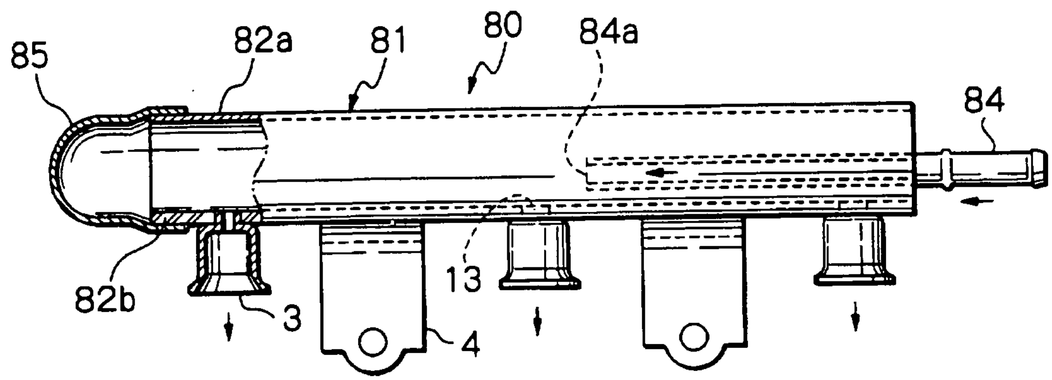


Fig. 8



FUEL DELIVERY RAIL ASSEMBLY

BACKGROUND OF THE INVENTION

This invention relates to a fuel delivery rail assembly for an internal combustion engine, especially for an automotive engine, equipped with an electronic fuel injection system. The fuel delivery rail assembly delivers pressurized fuel supplied from a fuel pump toward intake passages or chambers via associated fuel injectors. The assembly is used to simplify installation of the fuel injectors and the fuel supply passages on the engine. In particular, this invention relates to sectional constructions of a fuel conduit (fuel rail) having a fuel passage therein and connecting constructions between the conduit and sockets for receiving fuel injectors.

Fuel delivery rails are popularly used for electronic fuel injection systems of gasoline engines. There are two types of fuel delivery rails; one is the return type having a return pipe and another is the returnless (non-return) type. In the return type, fuel is delivered from a conduit having a fuel passage therein to fuel injectors via cylindrical sockets and then residual fuel goes back to a fuel tank via the return pipe. Recently, for economic reasons, the returnless type is used increasingly and new problems are arising therefrom; due to pressure pulsations and shock waves which are caused by reciprocal movements of a fuel pump (plunger pump) and injector spools, the fuel delivery rail and its attachments vibrate thereby emitting undesirable noise.

Japanese unexamined patent publication No. Hei 11-2164

entitled "a fuel delivery" refers to this problem and discloses a method of manufacturing the fuel delivery body by a steel press process for lowering the resonance rotation caused by the pressure pulsation below the idling rotation and thereby limiting the rigidity and the amount of space in the delivery body to a preselected range. However, in view of the fact that delivery bodies are ordinarily formed by a steel pipe having a circular section or rectangular section, it is difficult to make use of this known method in view of the specification, strength or cost of the engine.

Japanese examined patent publication No. Hei 3-62904 entitled "a fuel rail for an internal combustion engine" refers to a chattering noise associated with injectors and discloses a construction using a diaphragm which divides interior of the conduit into a socket side and a tube side thereby absorbing pressure pulsations and injector residual actions by its flexibility. However, in order to arrange the flexible diaphragm longitudinally within the conduit, seal members and complex constructions become necessary, so that overall configurations are relatively restricted. Consequently this known construction cannot be used in many types of engines.

Japanese unexamined patent publication No. Sho 60-240867 entitled "a fuel supply conduit for a fuel injector of an internal combustion engine" discloses a construction in which at least one wall of a fuel supply conduit is a flexible wall so as to damp fuel pressure pulsations, and the flexible wall is fixed to a rigid wall. However, since the flexible wall is fixed to the rigid wall, its flexibility is

not sufficient for obtaining preferable damping results.

SUMMARY OF THE INVENTION

It is an object of the present invention to provide a fuel delivery rail assembly which can reduce the pressure fluctuations within the fuel passages caused by fuel injections, and also to reduce the vibrations caused by fuel reflecting waves (shock waves), thereby to eliminate emission of uncomfortable noise and miscellaneous defects.

A conventional type of fuel delivery rail assembly comprises an elongate conduit having a longitudinal fuel passage therein, a fuel inlet pipe fixed to an end or a side of the conduit, and a plurality of sockets vertically fixed to the conduit adapted to communicate with the fuel passage and so formed as to receive tips of fuel injectors at their open ends.

According to the characteristics of the invention, outer walls of the fuel conduit include at least one flat or arcuate (arched) flexible first pressure or shock absorbing surface. The first pressure absorbing surface is smoothly and integrally connected to an arcuate second pressure or shock absorbing surface. One of these pressure or shock absorbing surfaces faces fuel inlet ports of the sockets which are adapted to receive tips of fuel injectors. Thus, fuel pressure pulsations and shock waves are reduced by abrupt enlargements (spatial expansions) of fuel passages and bending of the absorbing surfaces.

According to another feature, the transverse dimensions of the longitudinal fuel passage in the elongate conduit are such that the width of the fuel passage in the direction perpendicular to the clearance between each fuel inlet port and the facing absorbing surface is substantially a plurality of times the width of the fuel passage in the direction parallel to the said clearance.

Several embodiments of the invention are exemplified as follows:

(A) Each section of the conduit is formed in a flat

configuration comprised of flat portions and arcuate portions.

(B) Each section of the conduit is formed in a telephone receiver handset configuration.

(C) Each section of the conduit is formed in a character "T" configuration.

(D) Each section of the conduit is formed in a corrugation.

(E) Each section of the conduit is formed in a dumbbell configuration.

(F) Each section of the conduit is formed in a reverse eye mask configuration.

(G) The second absorbing surface is an arcuate flexible end cap fixed to a longitudinal end of the conduit.

As the results of the above constructions of the invention, in a fuel delivery rail assembly having a fuel conduit made by steel, stainless steel or conventional materials for press working, it has been found that it becomes possible to eliminate the emission of uncomfortable noise due to the vibration and pressure pulsations which are caused by the reflecting waves of injections and lacks of damping performance of the conduit.

According to a theoretical principle, when shock waves produced by the fuel injections flow into the fuel inlet of the sockets or flow away therefrom by momentary back streams, flexible absorbing surfaces would absorb the shock and pressure pulsations. In addition, when thin plates having small spring constant are deflected and deformed, the space of contents would vary, namely expand or shrink, thereby absorbing pressure fluctuations.

In a preferred embodiment, an inner end of the fuel inlet pipe terminates and opens near the center of the

longitudinal conduit. This position is adapted to obtain maximum deflections of the conduit, whereby deflections of the absorbing surfaces are increased so as to enhance shock absorbing performance. However, the position is preferably offset from the center of the socket in order to avoid direct transmission of fuel pressure pulsations.

In this invention, thickness of each wall of the conduit, ratio of the horizontal size (width) to the vertical size (height), and the range of clearance between the fuel inlet of the socket and its confronting surface are preferably defined by experiments or calculations such that, specially at the idling time of the engine, the vibrations and pressure pulsations become minimum.

Since the present invention is directed essentially to the sectional construction of the conduit and connecting construction of the conduit and the sockets, interchangeability to the prior fuel delivery rails are maintained as far as the mounting dimensions are kept constant.

Other features and advantages of the invention will become apparent from descriptions of the embodiments, when taken in conjunction with the drawings, in which, like reference numerals refer to like elements in the several views.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a frontal view of the fuel delivery rail assembly according to the invention.

FIG. 2 is a side view of the assembly of Fig. 1 and vertical sectional view along the socket.

FIG. 3 is a frontal view of the fuel delivery rail according to another embodiment.

FIG. 4 is a side view of the assembly of Fig. 3 and vertical sectional view along the socket.

FIG. 5 is a vertical sectional view illustrating several embodiments of the connection between the socket and rail sections.

FIG. 6 is a frontal view of the fuel delivery rail assembly according to another embodiment.

FIG. 7 is a vertical sectional view of the assembly of Fig. 6 along the socket.

FIG. 8 is a frontal view of the fuel delivery rail assembly according to another embodiment.

DESCRIPTION OF THE PREFERRED EMBODIMENT

Referring to FIG. 1, there is shown a preferable embodiment of the present invention, a fuel delivery rail assembly 1, so called as "top feed type", adapted to three cylinders on one side of an automotive V-6 engine. The fuel conduit (rail) 11 comprised of flat steel pipe extends along a longitudinal direction of a crank shaft (not shown) of an engine. At the side of the conduit 11, a fuel inlet pipe 2 is fixed with an intermediate connector 5 by brazing or welding. Although at an end of the conduit 11 it is possible to provide a fuel return pipe for transferring residual fuel back to a fuel tank, the present invention is directed to the non-return type rendering fuel pressure pulsation problems, so that the fuel return pipe is not provided.

At the bottom side of the conduit 11, three sockets 3 for receiving tips of fuel injectors are located corresponding to the number of cylinders at predetermined angles and distances from each other. To the conduit 11, thick and rigid two brackets 4 are fixed transversely so as to mount the assembly 1 onto the engine body. Fuel flows along the arrows thereby being discharged from the socket 3 and fuel injectors (not shown) into an air intake passage or cylinders of the engine.

FIG. 2A, 2B illustrate the side view of the assembly 1 of Fig. 1 and vertical section of the socket 3. Outer walls of the conduit 11 comprise a flat upper plate 12a, right and left arcuate side plates 12b, 12c which are smoothly and integrally connected to the upper plate 12a, and flat bottom plate 12d which is brazed or welded to the side plates 12b, 12c. The lower surface of the flat plate 12a faces the fuel inlet port 13 of the socket 3. As the characteristics of the invention, the flat plate 12a provides a flexible first pressure or shock absorbing surface and the right and left arcuate side plates 12b, 12c provide flexible second pressure or shock absorbing surfaces.

The vertical and horizontal dimensions of the conduit 11 can be defined such that each wall thickness is 1.5 mm, the height H is 5 mm, the width W is 46 mm. The spring constant of the flat construction 11 is about 40 kgf/cm square/mm. The clearance S between the fuel inlet port 13 and the lower surface of the flat plate 12a is less than 2 mm. As the results of continuous experiments, in which the dimensions are varied, it becomes apparent that the horizontal dimension (width) is preferably

5 to 10 times the size of the vertical dimension (height), and that the clearance S is preferably between 0.5 to 3mm. If the factor is less than 5, the spring constant becomes larger and its flexibility is reduced, whereby absorbing performance of pressure pulsations becomes defective. If **the factor** exceeds 10, a larger space becomes necessary for accommodating the fuel delivery rail assembly. If the clearance S is less than 0.5 mm, starting performance of the engine and accelerating performance become defective. If the clearance S is more than 3 mm, flexible performance becomes weak for deflecting the flat plate.

In addition, if the length L1, L2 from the center of the outer sockets 3 to each free end of the conduit 11 is larger than 30 mm, the deflections of the flat plates relative to the corresponding sockets 3 caused by the reflecting waves of the injection are smoothly enlarged thereby enhancing the shock absorbing performance.

According to the embodiment of Figs. 1 and 2, when shock waves flow into the fuel inlet port 13 of the sockets or flow away therefrom by momentary back streams, the pressure pulsations would be absorbed at the moment of release into the horizontal enlarged space. In addition, when thin absorbing surfaces 12a, 12b, 12c are deflected and deformed, the space of contents would vary and thereby absorb pressure fluctuations.

Fig. 3 illustrates a fuel delivery rail assembly 20 according to another embodiment of the invention. FIG. 4 shows a side view of the assembly 20 of Fig. 3 and vertical sectional view along the socket. The fuel conduit 21 is made in a flatly compressed arcuate sections through the process in which

a circular sectional stainless pipe is compressed vertically. The lower surface of the arcuate plate 22a faces the fuel inlet port 13 of the socket 3. At the end of the conduit 11, a fuel inlet pipe 2 is fixed with an intermediate connector 24 by brazing or welding.

As the characteristics of the invention, the flat portion 22a provides a flexible first pressure or shock absorbing surface and the right and left arcuate side portions 22b, 22c, which are smoothly and integrally connected to the flat surface 22a, provide flexible second pressure or shock absorbing surfaces. Further, the bottom portion 22d also provides a flexible third pressure or shock absorbing surface. In this embodiment, the flat portion 22a faces the fuel inlet port 13 of the sockets 3.

The vertical and horizontal dimensions of the conduit 21 can be defined such that each wall thickness is 1.2 mm, the height H is 6.4 mm, the width W is 32 mm. The spring constant of the flat construction 21 is about 65 kgf/cm square/mm. The clearance S between the fuel inlet port 13 and the lower surface of the flat plate 22a is less than 3 mm. As the results of continuous experiments, in which the dimensions are varied, it becomes apparent that the horizontal dimension is preferably 5 to 10 times the size of the vertical dimension, and that the clearance S is preferably between 0.5 to 3 mm.

In addition, if the length L from the center of the left socket 3 to the free end of the conduit 21 is larger than 30 mm, the deflections of the flat portions relative to the corresponding socket caused by the reflecting waves of the injection are smoothly enlarged thereby enhancing the shock absorbing performance.

According to the embodiment of Figs. 3 and 4, when shock waves flow into the fuel inlet port 13 of the sockets or flow away therefrom by momentary back streams, the pressure pulsations would be absorbed at the moment of release into the horizontal enlarged space. In addition, when thin absorbing surfaces 22a, 22b, 22c, 22d are deflected and deformed, the space of contents would vary and thereby absorb pressure fluctuations.

Fig. 5 illustrates several embodiments of sectional constructions between the rail sections and the socket. FIG. 5A shows the third embodiment of the invention, in which the vertical section of the conduit 31 is formed in a telephone receiver handset configuration which includes a thin flat portion 32a and downwardly convex portions 32b, 32c connected to both sides of the flat portion 32a. The flat portion 32a provides a flexible first pressure or shock absorbing surface and the right and left downwardly convex portions 32b, 32c, which are smoothly and integrally connected to the flat portion 32a, provide flexible second pressure or shock absorbing surfaces. In this embodiment, the flat portion 32a faces the fuel inlet port 13 of the socket 3.

FIG. 5B shows the forth embodiment of the invention, in which the section of the conduit 41 is formed in a character "T" which include thin flat portions 42a, 42b, 42c, 42d and arcuate portions 43a, 43b, 43c connected to the sides of the flat portions. The flat portion 42a provides a flexible first pressure or shock absorbing surface and the arcuate portion 43a, which is smoothly and integrally connected to the flat portion 42a, provides a flexible second pressure or shock absorbing surface, and other portions also provide flexible third or further pressure or shock absorbing

surfaces. In this embodiment, the flat portion 42a faces the fuel inlet port 13 of the socket 3.

FIG. 5C shows the fifth embodiment of the invention, in which the section of the conduit 51 is roughly formed in a corrugation. That is, the thin convex arcuate portion 52a is formed in a corrugation, and is smoothly and integrally connected to the right and left arcuate portions 52b, 52c. The arcuate portion 52a provides a flexible first pressure or shock absorbing surface and the arcuate portions 52b, 52c provide flexible second pressure or shock absorbing surfaces. The first absorbing surface 52a faces the fuel inlet port 13 of the socket 3.

FIG. 5D shows the sixth embodiment of the invention, in which the section of the conduit 61 is formed in a dumbbell configuration. That is, the thin flat neck portion 62a of the conduit 61 is connected smoothly and integrally to the right and left semi-circular portions 62b, 62c thereby providing a dumbbell configuration. The flat portion 62a provides a flexible first pressure or shock absorbing surface and the semi-circular portions 62b, 62c provide a flexible second pressure or shock absorbing surfaces. The first absorbing surface 62a faces the fuel inlet port 13 of the socket 3.

According to the embodiments of Figs. 5A to 5D, when shock waves flow into the fuel inlet port 13 of the sockets or flow away therefrom by momentary back streams, the pressure pulsations would be absorbed at the moment of release into the horizontal enlarged space. In addition, when thin absorbing surfaces 62a, 62b, 62c are deflected and deformed, the space of contents would vary and thereby absorbing pressure fluctuations.

FIG. 6 illustrates the fuel delivery rail assembly 70 according to another embodiment of the invention. FIG. 7 shows a vertical section of the assembly 70 of Fig. 6 along the socket. In this embodiment, the section of the conduit 71 is formed in a reverse eye mask configuration. That is, the central arcuate neck portion 72a is connected smoothly and integrally to the right and left arcuate portions 72b, 72c thereby providing a reverse eye mask configuration. The arcuate portion 72a provides a flexible first pressure or shock absorbing surface and the arcuate portions 72b, 72c provide flexible second pressure or shock absorbing surfaces. The first absorbing surface 72a faces the fuel inlet port 13 of the socket 3. To the lateral side of the conduit 71, a fuel inlet pipe 74 is fixed by brazing or welding.

According to the embodiment of Figs. 6 and 7, when the shock waves flow into the fuel inlet port 13 of the sockets or flow away therefrom by momentary back streams, the pressure pulsations would be absorbed at the moment of release into the horizontal enlarged space. In addition, when thin absorbing surfaces 72a, 72b, 72c are deflected and deformed, the space of contents would vary and thereby absorb pressure fluctuations.

As another characteristic of the invention, the inner end 74a of the fuel inlet pipe 74 terminates and opens near the center of the longitudinal conduit 71, and the fuel discharge position 74a is distant from the center of the socket 3 by a dimension of more than half width of the conduit 71. This arrangement intends to locate the fuel discharge at a maximum deflecting position of the conduit 71 thereby to enhance the pulsation absorbing performance. However, if the fuel discharge

position 74a is located too close to the fuel inlet port 13 of the socket 3, the pressure pulsations would be directly transmitted into the socket 3 without being reduced. The vertical and horizontal dimensions of the conduit 71 can be defined such that each wall thickness is 1.2 mm, the height is 13 mm, and the width is 30 mm.

In addition, if the length L from the center of the left socket 3 to the free end of the conduit 71 is larger than 30 mm, the deflections of the conduit 71 relative to the socket 3 caused by the reflecting waves of the injection are smoothly enlarged thereby enhancing the shock absorbing performance.

FIG. 8 illustrates a fuel delivery rail assembly 80 according to another embodiment of the invention. In this embodiment, the section of the conduit 81 is formed in a rectangular or circular configuration, which includes upper surface 82a of flexible thin plate, and rigid bottom plate 82b. At the longitudinal end of the conduit 81, a flexible cap member 85 is connected smoothly and integrally to the thin plate 82a. The thin plate 82a provides a flexible first pressure or shock absorbing surface and the cap member 85 provides a flexible second pressure or shock absorbing surface. The first absorbing surface 82a faces the fuel inlet port 13 of the socket 3. To the distal end of the conduit 81, a fuel inlet pipe 84 is fixed by brazing or welding, and its inner end 84a extends through the conduit 81.

According to the embodiment of Fig. 8, when the shock waves flow into the fuel inlet port 13 of the sockets or flow away therefrom by momentary back streams, the pressure

pulsations would be absorbed at the moment of release into the horizontal enlarged space. In addition, when the thin absorbing surface 82a is deflected and deformed, the space of contents would vary and thereby absorbing pressure fluctuations.

As another characteristic of the invention, the inner end 84a of the fuel inlet pipe 84 terminates and opens near the center of the longitudinal conduit 81, and the fuel discharge position 84a is distant from the center of the socket 3 by a dimension of more than half width of the conduit 81. This arrangement is intended to locate the fuel discharge at a maximum deflecting position of the conduit 81 thereby to enhance the pulsation absorbing performance.

The cap member 85 is made from plate materials such as SPCC, SPHC, SUS, which are identified by Japanese Industrial Standard, through a plastic working such as restriction working. The radius of curvature of the cap 85 is preferably more than 3 mm, from the view points of elasticity and strength. The vertical and horizontal dimensions of the conduit 81 can be defined such that thin plate thickness is 1.2 mm, the height is 25 mm, and the width is 20 mm.

CLAIMS

1. In a fuel delivery rail assembly for an internal combustion engine comprising; an elongate conduit having a longitudinal fuel passage therein, a fuel inlet pipe fixed to an end or a side of said conduit, and a plurality of sockets vertically fixed to said conduit adapted to communicate with said fuel passage and so formed as to receive tips of fuel injectors at their open ends, characterized in that:

outer walls of said conduit include at least one flat or arcuate flexible first pressure or shock absorbing surface,

said first absorbing surface is smoothly and integrally connected to an arcuate second pressure or shock absorbing surface, and

a said absorbing surface faces fuel inlet ports of said sockets, whereby;

fuel pressure pulsations and shock waves are reduced by abrupt enlargements of fuel passages and bending of said absorbing surfaces.

2. A fuel delivery rail assembly as claimed in claim 1, wherein each section of said conduit is formed in a telephone receiver handset configuration which includes a flat portion and downwardly convex portions connected to both sides of said flat portion.

3. A fuel delivery rail assembly as claimed in claim 1, wherein each section of said conduit is formed in a character "T" configuration, and each side of the T configuration includes a flat portion and an arcuate portion.

4. A fuel delivery rail assembly as claimed in claim 1, wherein each section of said conduit is formed in a corrugation which includes arcuate portions.

5. A fuel delivery rail assembly as claimed in claim 1, wherein each section of said conduit is formed in a dumbbell configuration which includes a flat portion and arcuate portions.

6. A fuel delivery rail assembly as claimed in claim 1, wherein each section of said conduit is formed in a reverse eye mask configuration which includes arcuate portions.

7. A fuel delivery rail assembly as claimed in claim 1, wherein said second absorbing surface is an arcuate flexible end cap fixed to a longitudinal end of said conduit.

8. A fuel delivery rail assembly as claimed in any of the claims 1 to 7, wherein an inner end of said fuel inlet pipe terminates and opens near the center of said longitudinal conduit with an offset from the centers of said sockets.

9. A fuel delivery rail assembly as claimed in any preceding claim, wherein the transverse dimensions of the longitudinal fuel passage in the elongate conduit are such that the width of the fuel passage in the direction perpendicular to the clearance between each fuel inlet port and the facing absorbing surface is substantially a plurality of times the width of the fuel passage in the direction parallel to the said clearance.

Application No: GB 0003718.4 **Examiner:** John Twin
Claims searched: 1 to 9 **Date of search:** 28 April 2000

Patents Act 1977
Search Report under Section 17

Databases searched:

UK Patent Office collections, including GB, EP, WO & US patent specifications, in:

UK Cl (Ed.R): F1B; F2P (PC1, PP9)

Int Cl (Ed.7): F02M 69/46

Other: online: EPODOC, JAPIO, WPI

Documents considered to be relevant:

Category	Identity of document and relevant passage		Relevant to claims
X	GB 2158512 A	(Robert Bosch)	1
A	US 5617827	(G M)	
A	US 5505181	(Siemens)	

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